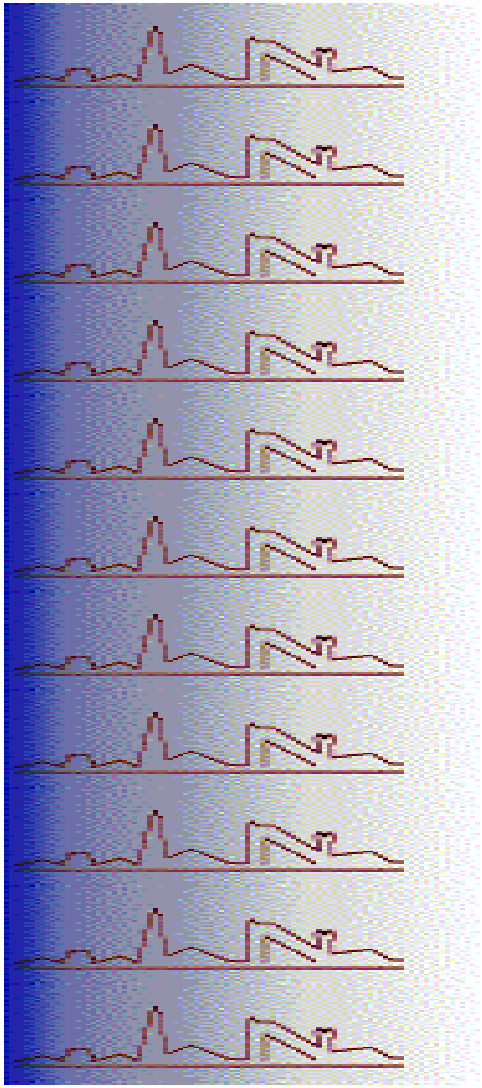
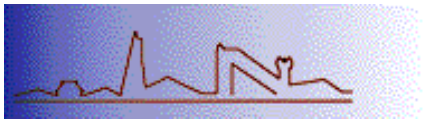


Workshop Summary: Instruments & Observations

Christoph U. Keller

(as John W. Harvey)

National Solar Observatory



Contents

- Background: SEC Roadmap and HRSOT
- Science questions and required observations
- Photon flux considerations
- Opportunities for space mission
- Strawman mission

SEC Roadmap: The Background

High-Resolution Solar Optical Telescope

Understanding flux tube characteristics provides insights about the Sun's magnetic field.

Fundamental Question:

- What are the dynamics of the flux tubes that drive atmospheric heating?

Science Objectives:

- Understand the internal structure, heating, and evolution of the Sun's magnetic flux tubes
- Understand the relationships between fine-scale photospheric magnetic activity and overlying regions
- Understand the changes in magnetic energy, structure, and helicity in active region magnetic fields

Mission Description:

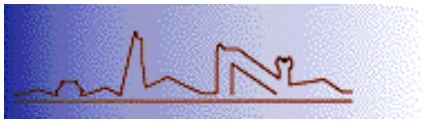
- Sun-synchronous, Earth-orbiting satellite

Measurement Strategy:

- Very-high-angular-resolution observations of intensity, velocity, and vector magnetic field
- EUV images of chromospheric and coronal structures

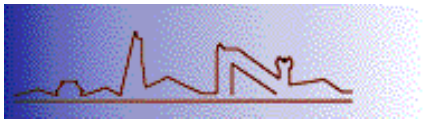
Technology Requirements

- High-data-rate communication
- Large-aperture optics and/or interferometers



Science Questions

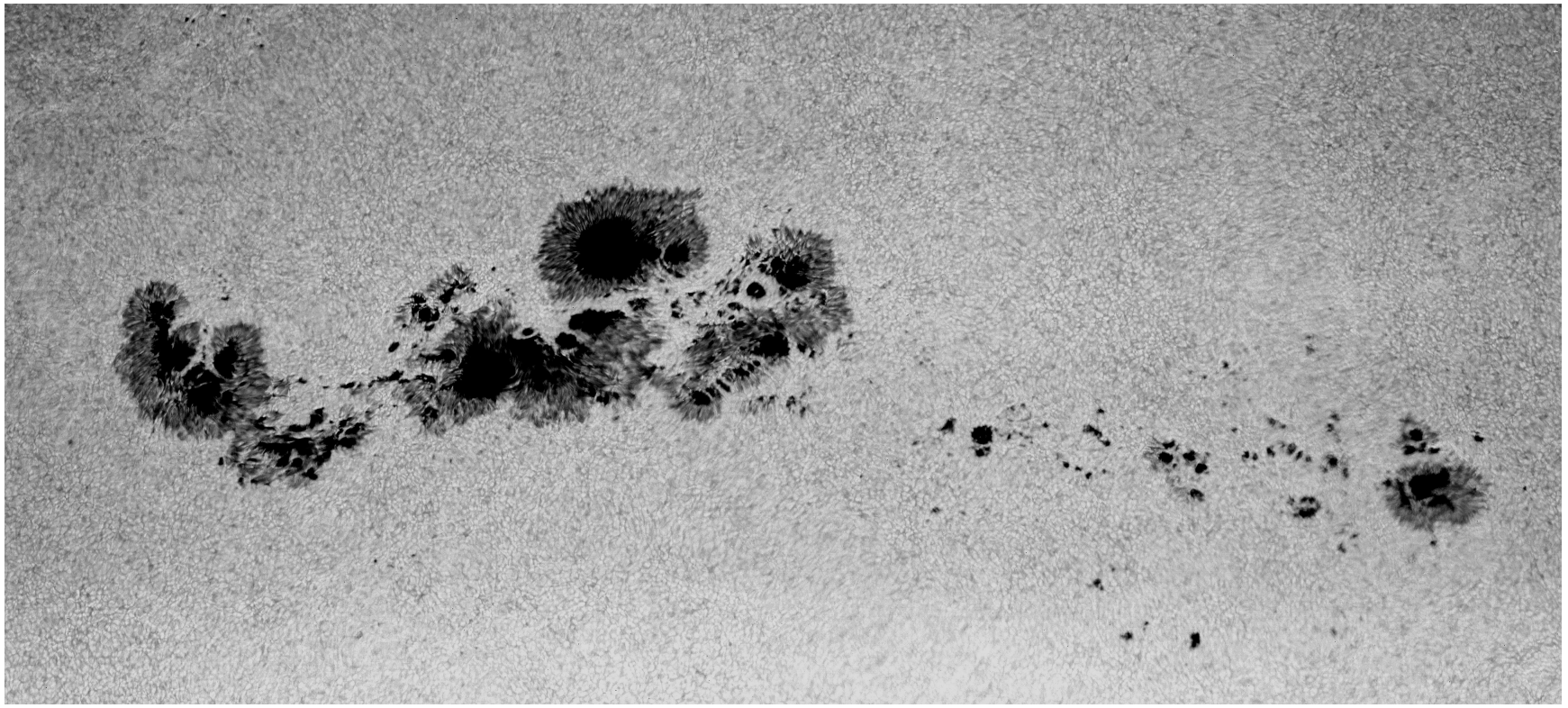
- “Do we have a powerplug?“
- Structure and nature of seismic events
- Nature and properties of local dynamo, true flux spectrum
- Property distributions of small-scale magnetic elements
- Evolution of active regions (“The only way to see AR emergence … you have to look for something else.“)
- Evolution of magnetic helicity
- Subphotospheric structure of sunspots and plages
- Nature of magnetoconvection in sunspots
- Everything about s…
- Structure and dynamics of transition region
- Connection of magnetic fields and energy channeling from photosphere to corona
- Processes heating the upper atmosphere
- Properties of coronal magnetic field ("trying to do the impossible“)
- What makes coronal fields unstable?



Observing Capabilities Wish List

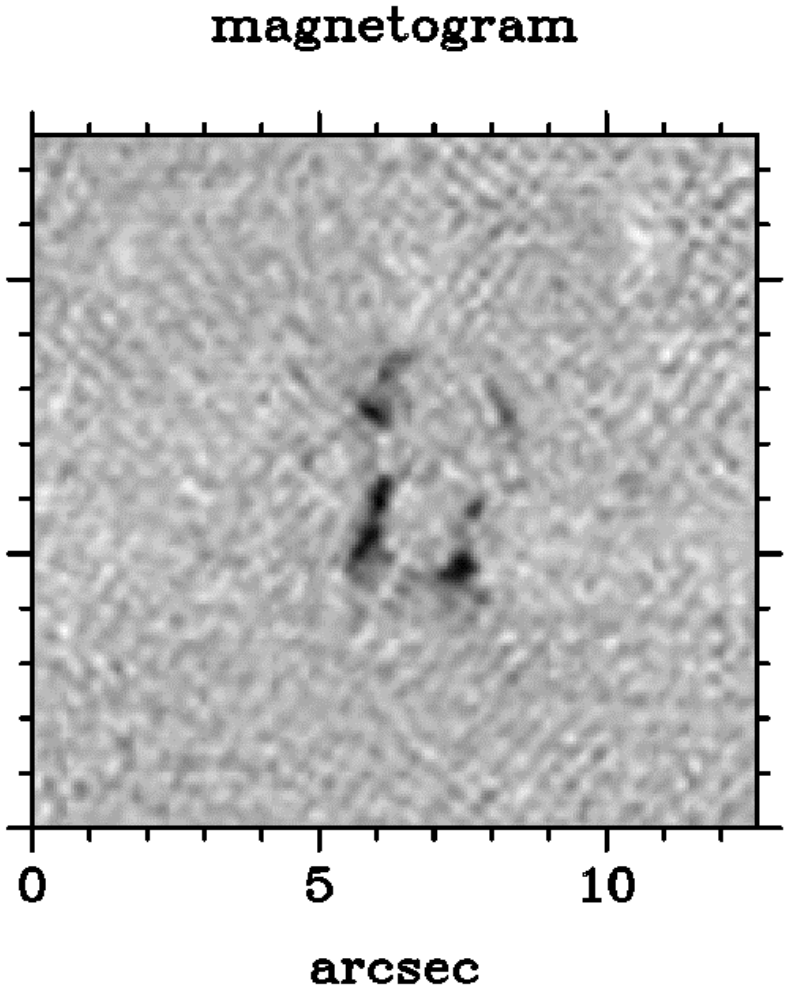
- "I want people and money"
- Higher spatial and temporal resolution than presently possible
- Higher polarimetric accuracy
- Field of view up to 8 arcmin
- Many lines simultaneously
- Spatial resolution of 10 km or better
- Temporal resolution of a second
- Transition Region spectrograph with high spatial resolution
- IR imaging spectropolarimetry 1-1.5 μm
- ATST in space

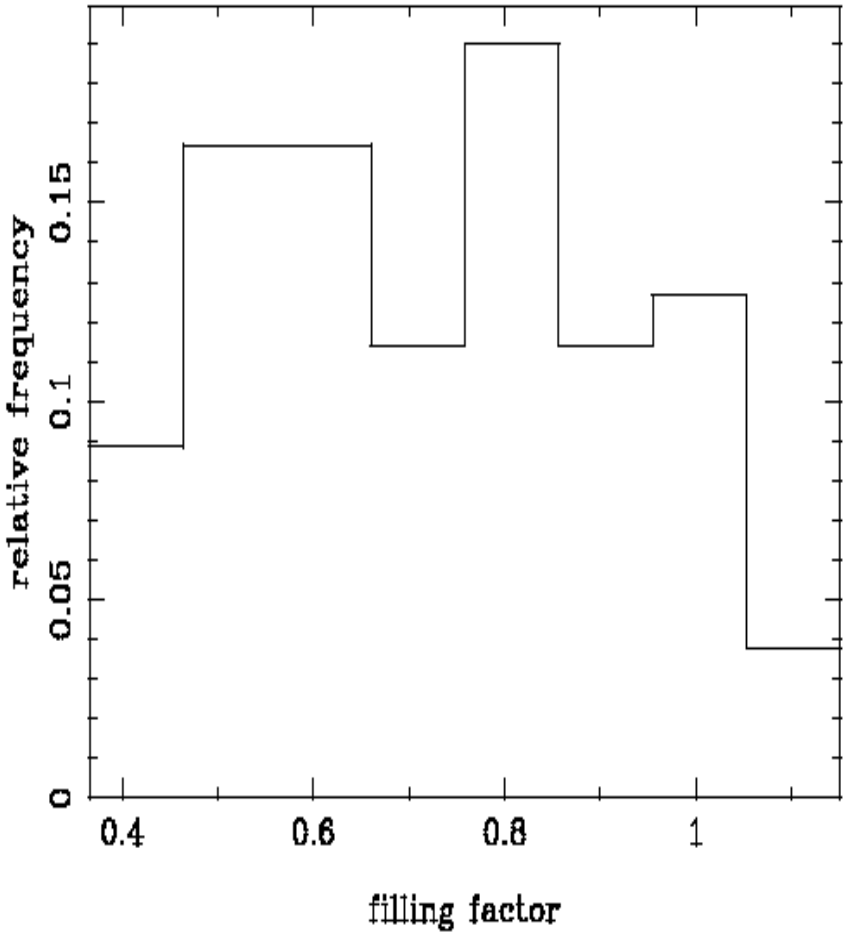
10 arcmin Field of View



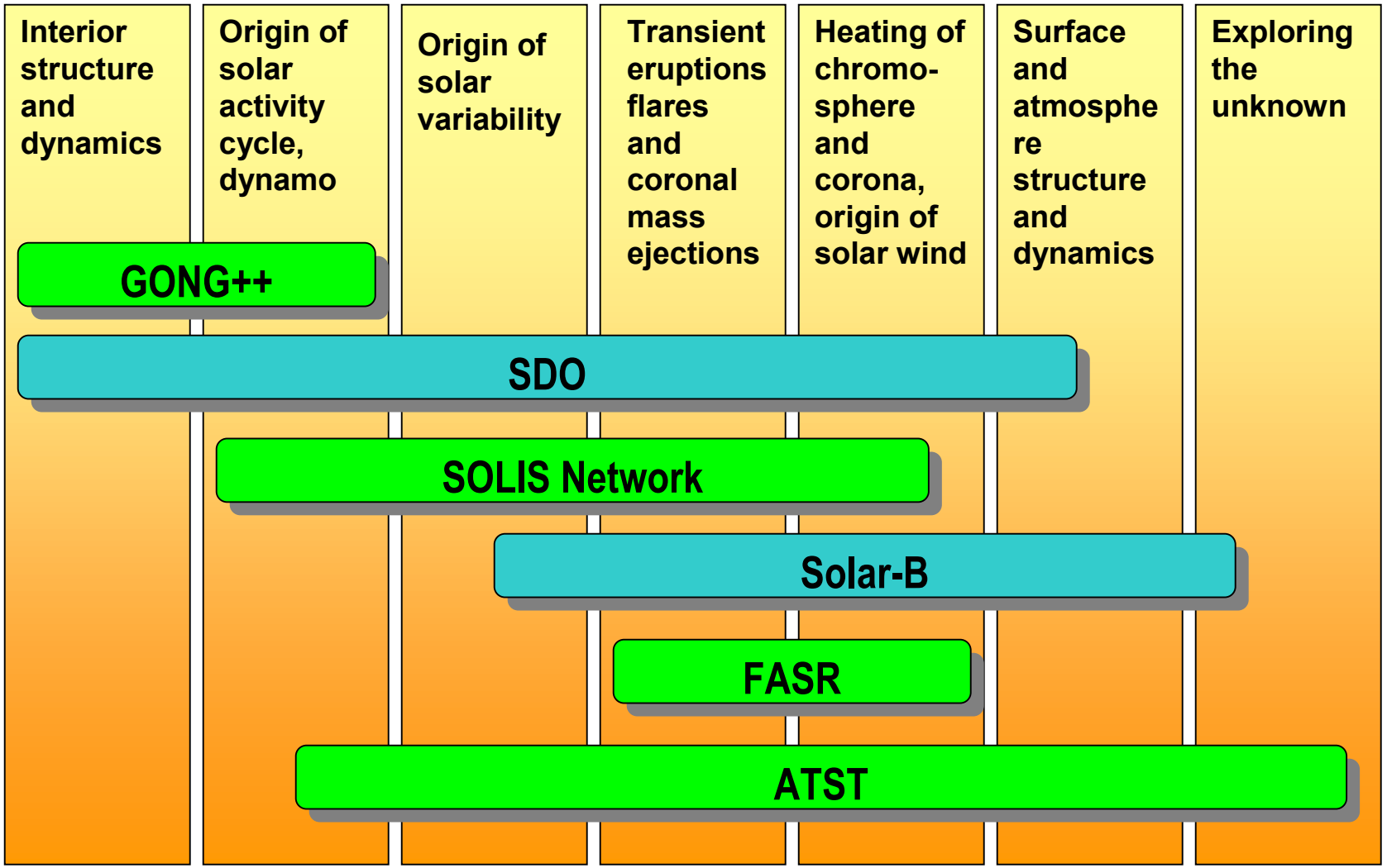
March 30, 2001, W.C.Livingston

Present Capabilities



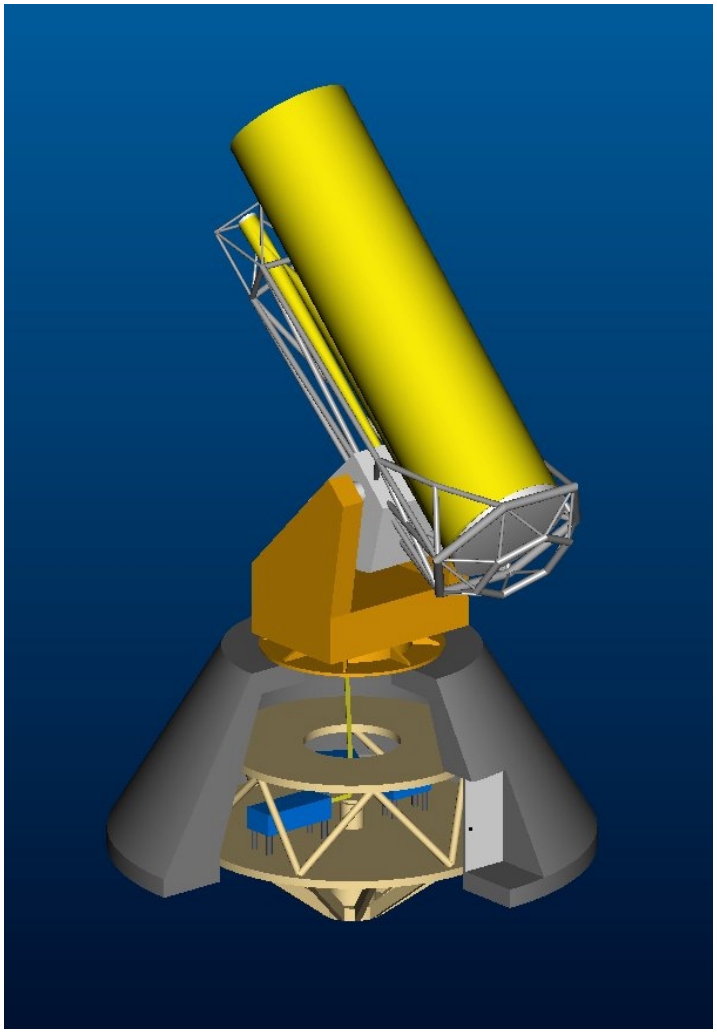


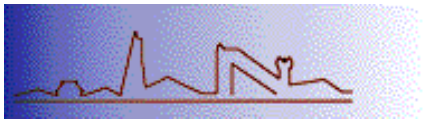
Solar Science and Missions Overview



Some Observing Capabilities in 2010

- Solar-B still operational
- ATST
  - Fully operational delivering 0.05 arcsec resolution over 10 arcsec
  - Covers the 300 nm to 30 μm wavelength range
  - To be upgraded with MCAO delivering 0.05 arcsec over 100 arcsec
- SOLIS Network: Provides full-disk vector-magnetograms every few hours 24 hours a day
- Solar Dynamics Observatory: Provides full-disk synoptic data including vector-magnetograms with 1 arcsec resolution
- Solar Orbiter to be launched within 2 years
- These facilities can address a large part of the science goals mentioned above



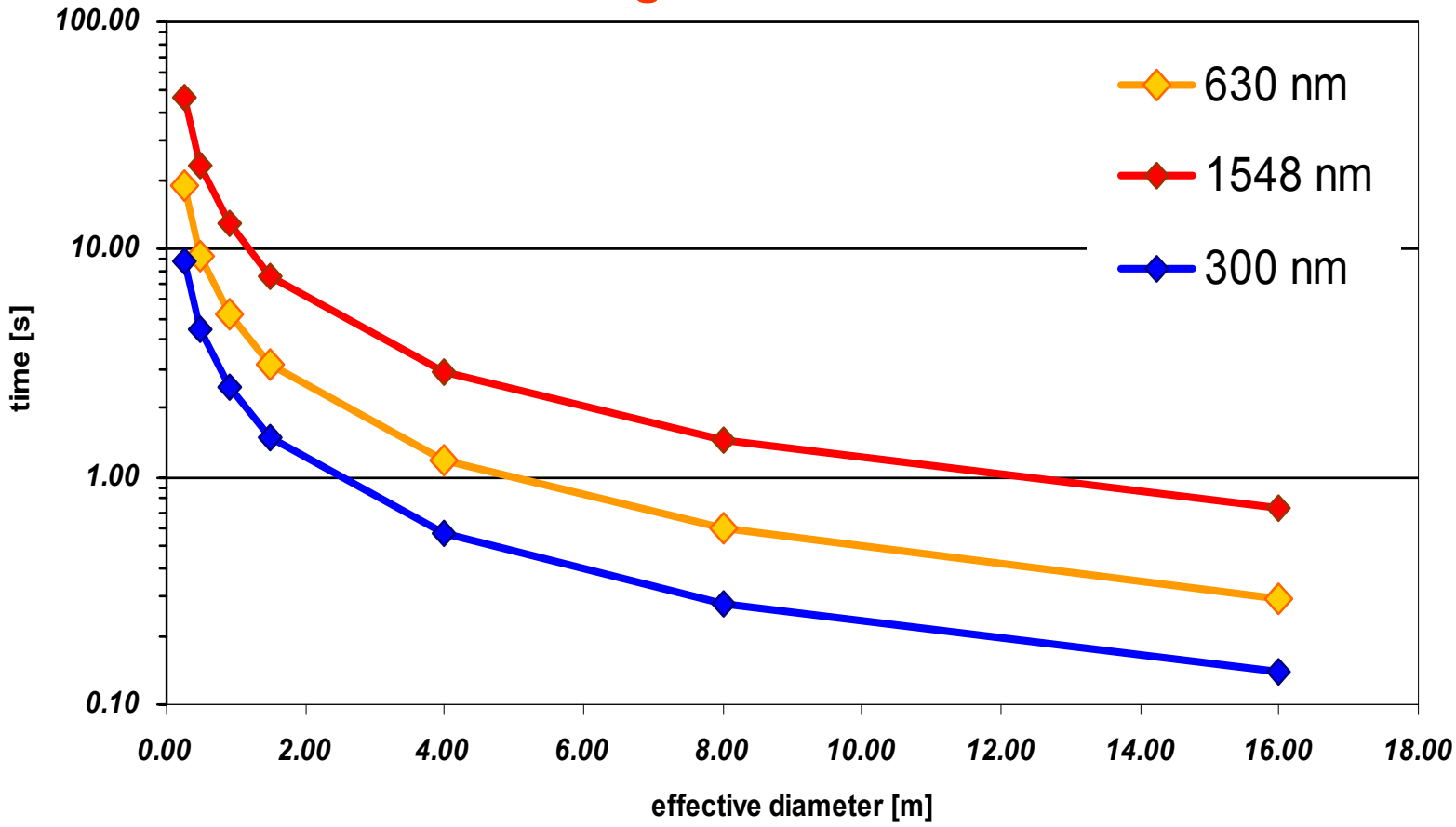


Photon Starvation at the Diffraction Limit

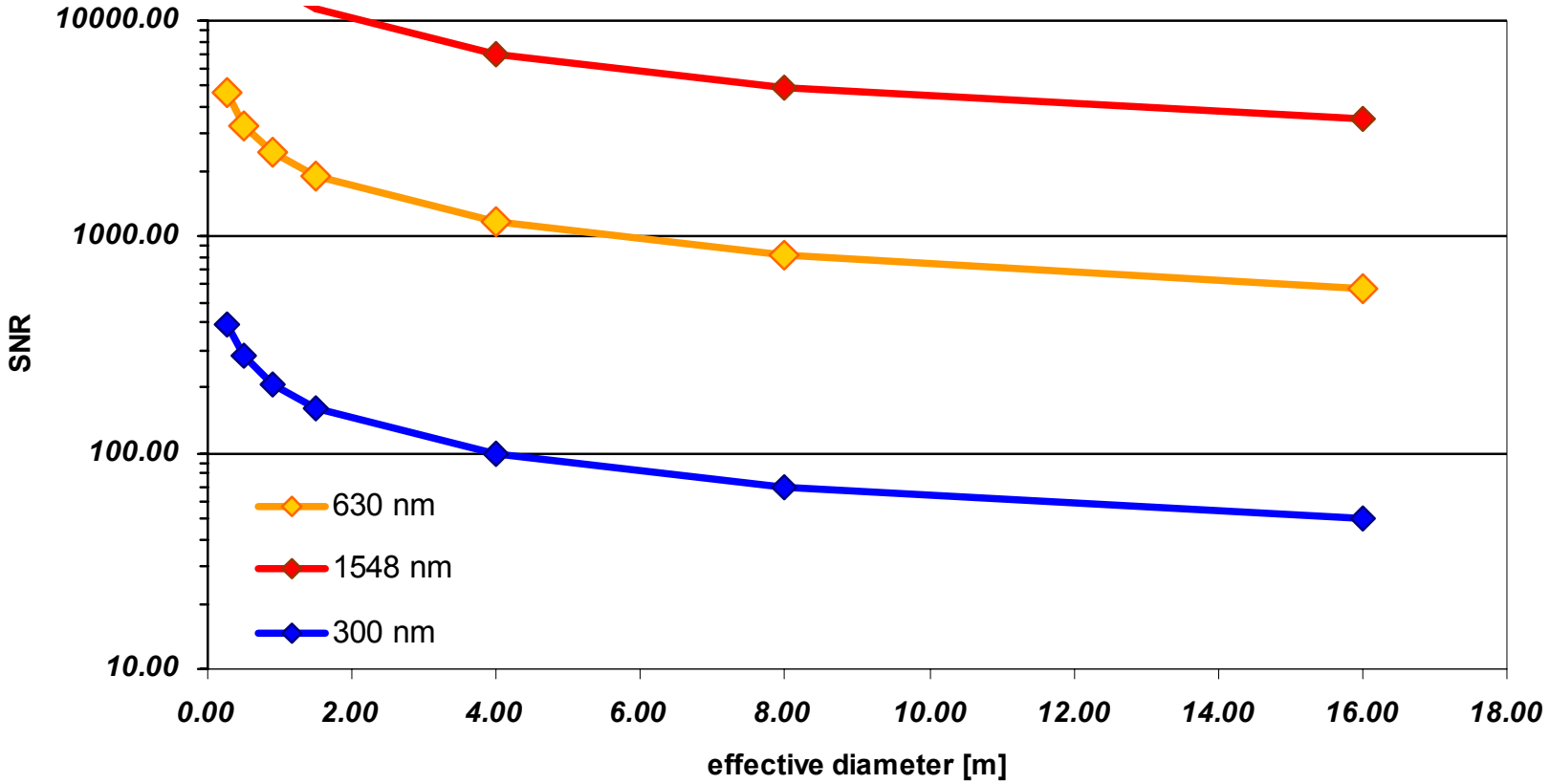
- Unobscured aperture
- 10% overall efficiency (including detectors)
- Maximum horizontal motion of 5 km/s
- Solar image is not allowed to evolve more than half a pixel
- Spectral resolution of 150,000
- Nyquist sampled in space (diffraction-limited) and spectrum
- Look at a single spatial and spectral pixel

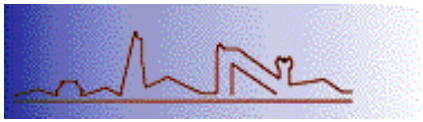
Maximum Integration Time

For a 4-m telescope, diffraction-limited data can only be integrated during about 1 second!



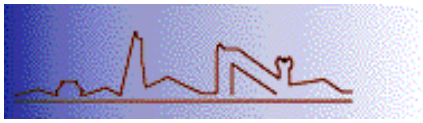
Maximum SNR at Diffraction Limit





Aperture Driver

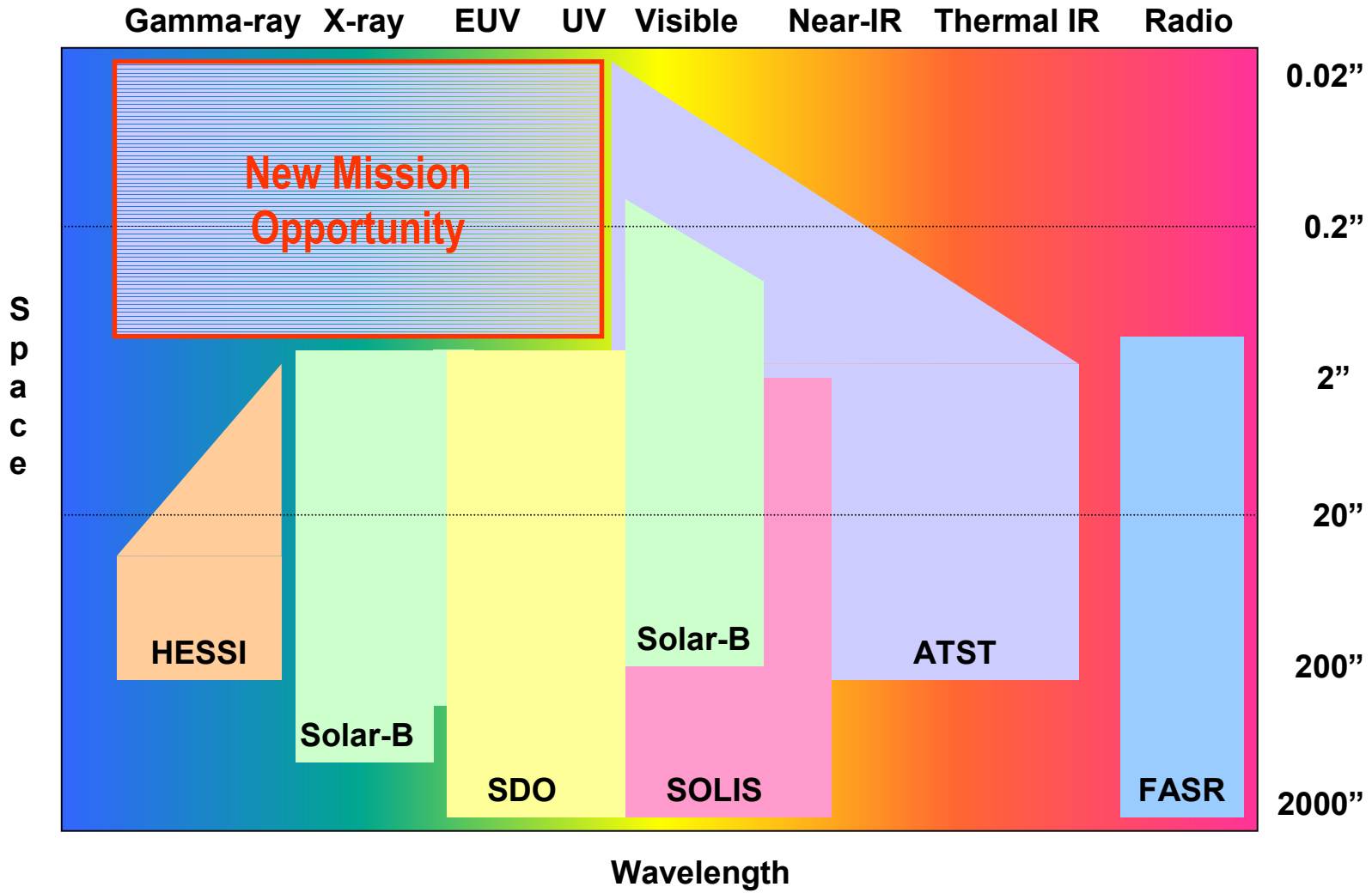
- High-resolution spectro-polarimetry is photon-starved
- The bigger the telescope, the smaller the maximum achievable SNR at the diffraction limit
- Photon flux rather than diffraction determines aperture size
- Interferometers will only provide very limited spectral resolution
- By 2010, it is unlikely to gain much in science capabilities from visible-light telescope in space



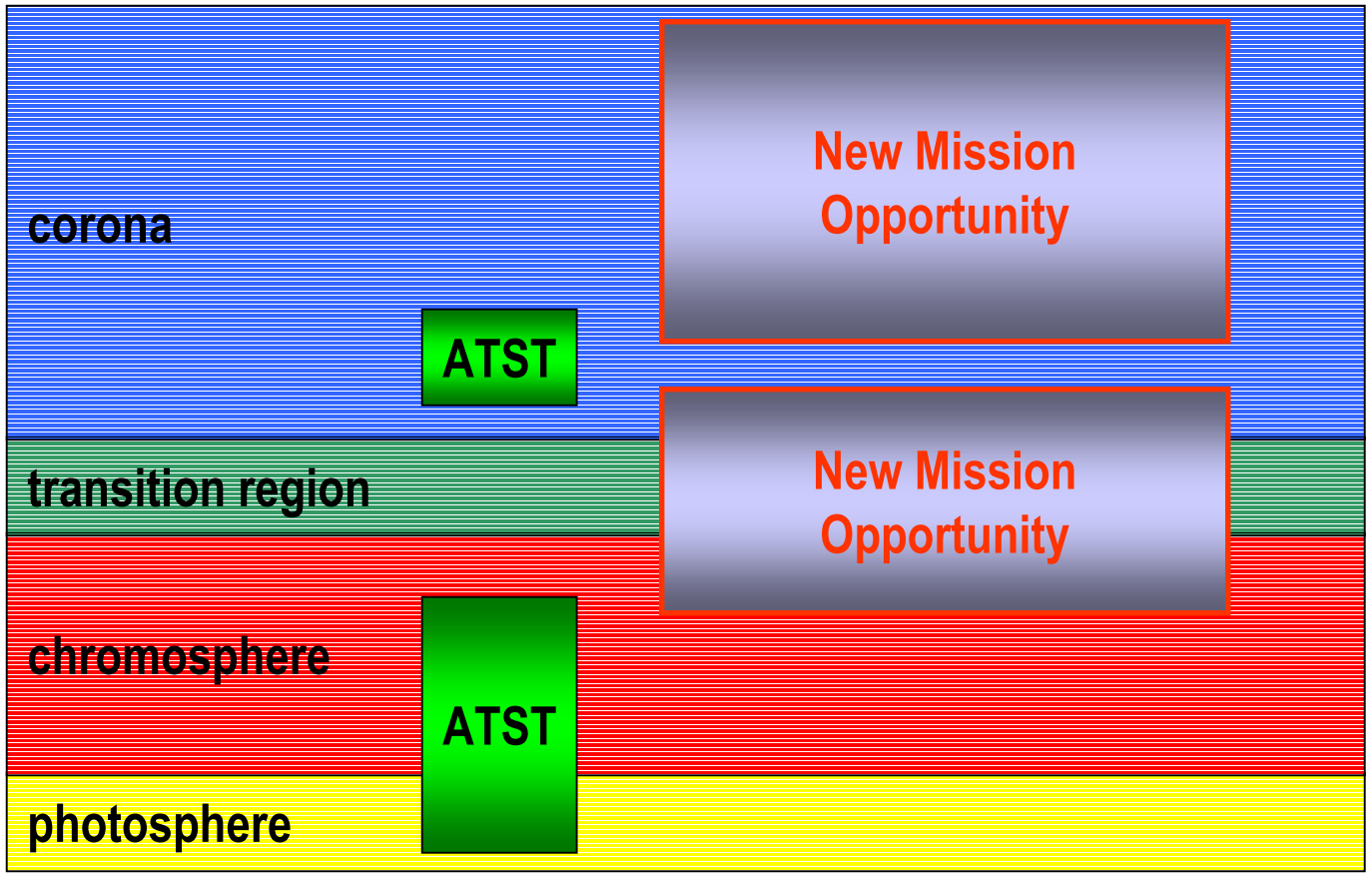
Advantages of Space

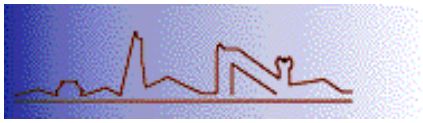
- Thanks to Ted Tarbell
- 24 hours of sunshine and good weather every day
- Perfect seeing over very large field of view
- Excellent uniformity of observing conditions
- Visible,UV, EUV,X-ray,IR instruments on the same platform

Spatial vs Wavelength Coverage



High-Resolution Coverage of Atmosphere





Advanced Solar Space Telescope: Science

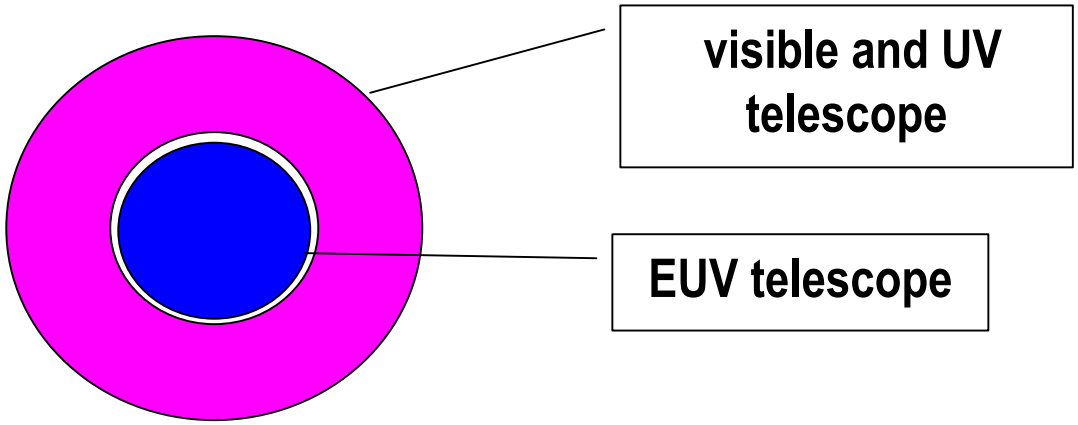
- Overall science goal:
  Understand the dynamic coupling of the magnetized solar atmosphere from the photosphere to the corona

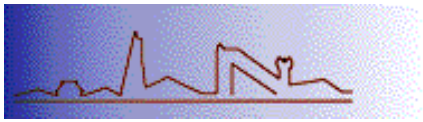
- Primary mission:
  Provide very high-resolution observations of those parts of the solar atmosphere that cannot be easily observed from the ground (upper chromosphere, transition region, corona on the disk)

- Secondary mission:
  Provide simultaneous high-resolution observations that can easily be correlated with ground-based data

Advanced Solar Space Telescope

- “avoid trying to come up with the instrument”
- 2-m class space telescope giving access to visible, UV, EUV, soft X-ray
- Research facility with high flexibility: spectrographs and filter-based instrument that can do polarimetry
- Combine with other Roadmap missions (?)
- "complicated thing full of optics, the kind of thing that Lockheed likes to build“





Thanks To

- Ron Moore
- John Davis
- David Hathaway
- Pat Corder
- Diane Nelms